APPLICATION OF MICROSUBSTRATES FOR MATERIALS PROCESSING

TECHNICAL FIELD

The present invention relates to materials processing methods. More particularly, the present invention relates to the adaptation of microsubstrates having arrays of individually controllable micro-hotplates to materials processing techniques.

BACKGROUND ART

Development of thin film materials conventionally involves subjecting macroscopic (>1 cm) samples to a sequence of deposition, lithographic and post-deposition processing steps. Microlithography technology has been used to isolate microscopic regions for deposition or etching of materials to produce different devices on a single wafer. However, during a given process the entire sample or wafer is held at given temperature. Wafer processing sequences are constrained by "thermal budgets" in which processing steps for the wafer are limited by the lowest maximum temperature tolerance of any other device or layer on the wafer.

From another point of view, scientific studies to optimize a process sequence for a thin film (for coating or device applications, for example), usually involve successive runs through a cycle using varying process temperatures for each run. Since process steps involve mounting the sample in a chamber for controlled environments (high vacuum, furnace, plasma etching, etc.) a full cycle for one sample may require a day or longer to process.

Using micro-machining techniques, it has become possible to create small (<0.1 mm) structures on silicon wafers that are thermally isolated from the rest of the wafer. These structures may be equipped with microlithographically-defined heater elements to reach temperatures in excess of 1000° C., while the rest of the wafer is at ambient room temperature. A recent example is the integrated multi-element gas analyzer by Najafi et al (N. Najafi, K. D. Wise, R. Merchant, and J. W. Schwank, IEEE Workshop on Sensors, Hilton Head, S.C., 1992), pp. 19). This work uses micromachining techniques to fabricate an integrated heater, metal dispersant layer, silicon temperature sensor, and gas-sensing film. The heating element is used to thermally activate sensing adsorption/desorption phenomena occurring on the gas-sensing film surface. Use of the heater to process materials was not considered. The technique used to fabricate the structure was a special process that does not take advantage of low-cost commercial foundry capabilities.

DISCLOSURE OF THE INVENTION

It is accordingly one object of the present invention to provide a method of characterizing materials.

Another object of the present invention is to provide a method of investigating micro-samples (<1 cm) of materials.

A further object of the present invention is to provide a method of preparing a plurality of micro-samples.

It is a further object of the present invention to provide a method of preparing a plurality of micro-samples on a single substrate which have different characteristics.

A still further object of the present invention is to provide a method of preparing a plurality of micro-samples for investigation.

A still further object of the present invention to provide a method of maskless lithography.

According to these and further objects of the present invention which will become apparent as the description thereof proceeds, there is provided a method of preparing a plurality of micro-samples of materials for investigation which involves:

providing a substrate having a plurality of micro-hotplates, wherein each of the plurality of micro-hotplates can be individually temperature controlled; and

depositing a material film on the plurality of micro-hotplates while thermally cycling selected ones of the plurality of micro-hotplates to form a micro-sample on each of the plurality of micro-hotplates.

The present invention further provides a method of characterizing material properties which involves:

providing a substrate having a plurality of micro-hotplates, wherein each of the plurality of micro-hotplates can be individually temperature controlled;

depositing a material film on the plurality of micro-hotplates while thermally cycling selected ones of the plurality of micro-hotplates to form a micro-sample on each of the plurality of micro-hotplates; and

characterizing properties of the micro-samples.

BRIEF DESCRIPTION OF DRAWINGS

The present invention will hereafter be described with reference to the annexed drawings which are given by way of non-limiting examples only in which:

FIG. **1A** is a schematic drawing showing the open areas and the heating element according to one embodiment of the present invention.

FIG. **1B** is a schematic drawing showing an alternative embodiment of the heating element.

FIG. **2** is a schematic drawing showing the conductive heat distribution plate with four point contacts according to one embodiment of the present invention.

FIG. **3** is a schematic drawing of the second level of metal contacts according to one embodiment of the present invention.

FIG. **4** is a schematic cross-sectional view of the micro-hotplate according to one embodiment of the present invention.

FIG. **5** is a schematic drawing of an array of four micro-hot plates on a single substrate according to the present invention.

FIGS. **6A**, **6B** and **6C** are scanning electron micrographs of SnO_2 grown on microsubstrates that were heated to room temperature (**6A**), 300° C. (**6B**) and 500° C. (**6C**), respectively during deposition.

BEST MODE FOR CARRYING OUT THE INVENTION

A commercial CMOS process has recently been developed at the National Institute of Standards and Technology (NIST) to form micro-heater structures using commercial foundries designed to produce application specific integrated circuits (ASIC). This technology allows lamp drivers and multiplexers to be mounted on a single chip as the microlamps using existing technology. These structures were designed to produce microlamp arrays, to be used for infrared-visible displays. A CMOS process for micromachining a thermo-